A General Formalism For Calculating the Radio Opacity of Ammonia Vapor In Giant Planet Atmospheres

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For decades researchers examining giant planet atmospheres at radio wavelengths have lacked a single ammonia vapor opacity formalism that was usably accurate over the entire radio spectrum and at all appropriate temperatures and pressures. Van-Vleck Weisskopf-based formalisms perform well at low pressures (less than ~0.5 bar) but poorly at higher pressures. Ben-Reuven-based formalisms, designed to overcome the problems at higher pressures, do unexpectedly poorly at low pressures. Calculations based on ammonia's inversion spectrum can do well at cm wavelengths, but understate absorption at mm and shorter wavelengths due to contributions from the low-frequency tails of IR and Far-IR rotational and ro-vibrational lines. The result to date is that the best available means of calculating ammonia opacities is a patchwork of formalisms, each covering the region of parameter space it handles best. In some cases the boundaries between these regions are artificial and awkward. Early '90's laboratory data by the author on ammonia opacity at cm wavelengths have revealed the source of the Ben-Reuven-based formalisms' breakdown at low pressures: the "line mixing" phenomenon does not decrease linearly to zero as pressure decreases. It decreases faster than linearly as pressure drops below ~2 bars of hydrogen, and quadratically for pressures below ~0.5 bar. A new formalism based on that result allows seamless opacity calculations from pressures of essentially zero to as high as is appropriate to giant planet radio astronomy. Adding IR-line calculations extends its range of applicability from mm to extremely long wavelengths. The new extended formalism will be presented, along with recommendations for its application. This work was performed by the author at the Jet Propulsion Laboratory/California Institute of Technology, under a grant from the National Aeronautics and Space Administration.